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TRANSILLUMINATOR

SPECIFICATION

Background of the Invention

This is a Continuation-In-Part Application of co-pending U. S. Application Serial No. 10/015,427 filed December 12, 2001.

Field of the Invention

The present invention relates generally to radiation devices. More particularly, the invention concerns an apparatus for irradiating various articles with ultra-violet radiation from a radiation source such as a plurality of ultra-violet lamps.

Discussion of the Prior Art

Ultra-violet radiation is widely used in industry and science for sterilization through inactivation of microorganisms, for inducing and promoting various types of photochemical reactions and for controllably exposing various types of photosensitive materials. By way of example, U.S. Patent No. 5,175,347 issued to the present inventor describes an apparatus for irradiating an object such as a specimen of material with ultraviolet radiation at a selected long, short or mid-wave length. Similarly, Patent No. 3,936,186 issued to Boland et al discloses an

apparatus for exposing diazo printing plates and the like of the character that are used in the graphic arts field. In like manner, U.S. Patent No. 5,288,647 issued Zimlich, Jr. et al relates to a method by which polynucleotide specimens can be irradiated particularly for the purpose of fixing them to a substrate.

Ultraviolet light (UV), which is electromagnetic radiation in the region of the spectrum located between X-rays and visible light, is typically divided into three principal ranges, namely long wave, mid-range, and short wave. For each of these UV ranges specific applications have been developed.

As a general rule, the desired ultraviolet wavelength is obtained from a fluorescent style tube that is an electric discharge device that uses a low-pressure mercury vapor arc to generate ultraviolet energy. The ultraviolet energy released in typical, commercially available fluorescent tubes is primarily at the wavelength of about 254 nanometers. The fluorescent tubes can be modified to release other ultraviolet wavelengths by the use of phosphors, which have the ability to absorb the ultraviolet energy and re-radiate it in other wavelengths. For example, long wave ultraviolet of about 365 nanometers and mid-range ultraviolet of about 300 nanometers are created by coating the inside of the fluorescent tubes with the proper phosphors which convert the short wave ultraviolet.

In the past ultraviolet irradiation of selected articles has been accomplished using single or multiple UV range fluorescent tubes mounted within a suitable

enclosure. In order to eliminate white light generated by the UV tube, some prior art devices make use of a UV transmitting, ambient or white or visible light blocking filter that is typically mounted in front of the UV tube.

In the past, when it was desired to obtain two UV wave lengths from the radiation device, two UV tubes emitting two levels of UV radiation were mounted side by side within the device, and an appropriate filter was placed in front of each tube.

In the apparatus disclosed in the previously identified U.S. Patent No. 5,175,347 issued to the present inventor, a different and novel technique was used to irradiating an object, with ultraviolet radiation at a selected long, short or mid-wave length. More particularly, in this prior art apparatus, a plurality of ultraviolet sources, each emitting radiation at a different wave length, were mounted within a rotatable array so that a selected one of the sources could be moved into alignment with the specimen and automatically energized by merely rotating the array.

As will be better understood from the discussion that follows, the present invention enables the controlled irradiation of a specimen with UV at selected wavelengths through the use of a novel wavelength conversion means that can be interposed between the UV source and the specimen.

Summary of the Invention

It is an object of the present invention to provide an apparatus for expeditiously irradiating an object with ultraviolet radiation at a selected UV wavelength.

More particularly, the apparatus of the invention comprises a plurality of ultraviolet sources, each emitting radiation at a first wave length. The UV sources are mounted within a housing that also supports a novel conversion plate that can be interposed between the UV sources and the specimen and functions to convert the UV to a second wavelength.

Another object of the invention is to provide an apparatus of the aforementioned character in which the conversion plate is slidably carried by the housing.

Another object of the invention is to provide an apparatus as described in the preceding paragraphs in which the specimen can be irradiated with ultraviolet radiation at a selected wavelength between about 254 nanometers about 312 nanometers and about 365 nanometers as well as combinations of these wavelengths and selected wavelengths from the visible spectrum.

Still another object of the invention is to provide an apparatus of the class described, which includes strategically located reflectors for reflecting the ultraviolet radiation in a direction toward the specimen. Another object of the

invention is to provide an apparatus as described in the preceding paragraphs in which a filter for blocking white light from the UV sources is interposed between the specimen and the UV sources.

Another object of this invention is to provide a platform that transmits selected UV visible or infrared wavelengths on which an irradiated sample rests, which is separate from the UV transmitting filter and/or white light blocking filter.

Another object of the invention is to provide an apparatus that will readily convert one UV radiation provided by a conventional UV lamp source into a second UV or combination UV/visible wavelength.

A further object of the invention is to provide in combination a UV transmitting apparatus of the character described herein and a separate UV transparent work-surface.

Yet another object of the invention is to provide an apparatus of the character described which is of a simple, compact construction that is easy to use and can be inexpensively manufactured.

Brief Description of the Drawings

Figure 1 is a generally perspective view of one form of the apparatus of the invention for irradiating an object with ultraviolet radiation.

Figure 2 is a generally perspective, exploded view of the apparatus shown in

figure 1.

Figure 3 is a top plan view of the apparatus shown in figure 1.

Figure 4 is a cross-sectional to take along lines 4-4 figure 3.

Figure 5 is a side elevational view of the apparatus shown in figure 1.

Figure 6 is an end view of the apparatus shown in figure 1.

Figure 7 is a cross-sectional view taken along lines 7-7 of figure 6.

Figure 8 is a cross-sectional view taken along lines 8-8 of figure 5.

Figure 9 is a cross-sectional view taken along lines 9-9 in figure 5.

Figure 10 is a generally perspective view of an alternate form of the apparatus of the invention.

Figure 11 is a transverse, cross-sectional view of the form of the apparatus shown in figure 10.

Figure 12 is a cross-sectional view taken along lines 12-12 figure 11.

Figure 13 is a generally perspective, exploded view of the alternate form of the apparatus shown in figure 10.

Figure 14 is a transverse cross-sectional view of another form of the apparatus of the invention.

Figure 15 is a cross-sectional view taken along lines 15-15 of figure 14.

Figure 16 is a transverse cross-sectional view of still another form of the apparatus of the invention.

Figure 16A is a side-elevational view of an alternate form of conversion plate of the invention.

Figure 16B is a side-elevational view of still another form of conversion plate of the invention.

Figure 16C is a side-elevational view of yet another form of conversion plate of the invention.

Figure 16D is a side-elevational view of still another form of conversion plate of the invention.

Figure 17 is a cross-sectional view taken along lines 17-17 of figure 16.

Figure 18 is a transverse cross-sectional view of another form of the apparatus of the invention.

Figure 19 is a cross-sectional view taken along lines 19-19 of figure 18.

Figure 20 is a transverse cross-sectional view of yet another form of transilluminator apparatus of the invention.

Figure 21 is a cross-sectional view taken along lines 21-21 of figure 20.

Figure 22 is a transverse cross-sectional view of yet another form of the apparatus of the invention.

Figure 23 is a cross-sectional view taken along lines 23-23 of figure 22.

Figure 24 is a generally perspective view of one form of a coated screen component that is usable in the apparatus of the invention for irradiating an object

with ultraviolet radiation.

Figure 25 is a cross-sectional view taken along lines 25-25 of figure 24.

Description of the Invention

Referring to the drawings and particularly to figures 1 through 9, one form of the irradiation apparatus of the present invention is there illustrated and generally designated by the numeral 12. The apparatus of this form of the invention comprises a housing 14 having interconnected top, bottom and sidewalls 16, 18, and 20 respectively that define an internal chamber 22. Carried by top wall 16 is filter means filter for blocking white light from the UV sources 24 that are disposed within internal chamber 22. The filter means here comprises a UV transmitting light blocking filter 26. Filter 26 is adapted to carry an article, such as a specimen that is to be irradiated as, for example, a ploynucleocide.In the present form of the invention, filter 26 blocks white light.

As best seen in figure 2, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit UV radiation at a first wavelength of, for example, 254 nanometers. Positioned between the array of lamps 24a and filter 26 is the highly novel first wavelength conversion means of the invention which is adapted to convert the UV radiation at the first wavelength to UV radiation at a second wavelength of, for example, about 365 nanometers or

about 312nm. This first wavelength conversion means here comprises a conversion plate 28 that is removably carried by housing 14 at a location intermediate filter 26 and UV source 24. More particularly, plate 28 is provided with a wave shifting phosphor coating 30 (figures 4 and 7) and is slidably movable within a slot 32 formed in housing. With this construction, plate 28 can be readily removed from the housing and replaced with another plate if desired. As is well known in the art, phosphors are compounds that are capable of emitting useful quantities of radiation in the visible and/or ultraviolet spectrums upon excitation of the material by an external energy source. Due to this property, phosphor compounds have long been utilized in cathode ray tube (CRT) screens for televisions and similar devices. Typically, inorganic phosphor compounds include a host material doped with a small amount of an activator ion. In recent years, phosphor compounds, including phosphors in particulate form, have been used in display devices, decorations, cathode ray tubes, and fluorescent lighting fixtures. Luminescence or light emission by phosphor particles may be stimulated by application of heat (thermoluminescence), light (photoluminescence), high energy radiation (e.g., x-rays or e-beams), or electric fields (electroluminescence). A comprehensive discussion of various types of phosphors can be found in Patent No. 6,193,908 issued to Hampden-Smith et al.

Turning to figures 10 through 13, an alternate form of transilluminator of the invention is there shown. This form of the invention is similar in many respects to that shown in figures 1 through 9 and like numerals are used in figures 10 through 13 to identify like components. This alternate form of the invention comprises a housing 34 having interconnected top, bottom and sidewalls 36, 38, and 40 respectively that define an internal chamber 42. Carried by top wall 36 is filter means filter for blocking white light from the UV sources 24 that are disposed within internal chamber 42. The filter means here comprises a UV transmitting white light blocking filter 26. As before, filter 26 is adapted to carry an article, such as a specimen that is to be irradiated.

As best seen in figure 11, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit UV radiation at a first wavelength of, for example, 254 nanometers. Lamps 24a are here positioned over a corrugated reflector 45. For certain application, reflector 45 can also be flat or dimpled. Positioned between the array of lamps 24a and filter 26 are first and second wavelength conversion means which are adapted to convert the UV radiation at the first wavelength to UV radiation at a second wavelength of, for example, about 312 nanometers and then to UV radiation at a third wavelength of, for example, about 365 nanometers. This first wavelength conversion means here comprises a first conversion plate 48 that is removably carried by housing 34

within a slot 49 at a location intermediate filter 26 and UV source 24. In this instance, plate 48 is provided with a wave shifting phosphor coating 50 (figures 11 and 12) and is slidably movable within the slot 49 that is formed in housing. The second wavelength conversion means of this latest form of the invention comprises a second conversion plate 54 that is also removably carried by housing 34 within slot 49. Plate 54 is provided with a wave shifting phosphor coating 56 (figures 11 and 12) and is slidably movable within the slot 49. Plate 54 is disposed at a location intermediate plate 48 and filter 26 in the manner shown in the drawings. With the construction shown, either or both plates 48 and 54 can be readily removed from the housing and replaced with alternate plates if desired.

Referring now to figures 14 and 15, another form of transilluminator of the invention is there shown for controllably irradiating with ultraviolet radiation for use in controllably irradiating an object with ultraviolet radiation This form of the invention, which separates the UV producing components from the sample to be exposed, is similar in many respects to that shown in figures 10 through 13 and like numerals are used in figures 14 and 15 to identify like components. This alternate form of the invention comprises a housing 64 having interconnected top, bottom and sidewalls 66, 68, and 70 respectively that define an internal chamber 72. Carried by top wall 66 is a UV transmitting, light blocking element 74 here provided in the form of a borosilicate glass. Element 76 includes a generally planar

upper surface 74a that is adapted to carry an article, such as a specimen that is to be irradiated.

Borosilicate glass, or light blocking element 74, functions to create a platform that minimizes the transmission of 254nm ultraviolet radiation, while effectively transmitting a midrange 312nm ultraviolet and above. It is to be understood that blocking element 74 can be constructed of a quartz material, fused silica, a hard glass, such as chemical Pyrex, lime glass, sapphire glass or ultraviolet transmitting or minimizing Plexiglass.

As illustrated in the drawings, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit UV radiation at a first wavelength of, for example, 254 nanometers. Positioned between the array of lamps 24a and element 74 are first and second wavelength conversion means which are adapted to convert the UV radiation at the first wavelength to UV radiation at a second wavelength of, for example, about 312 nanometers and then to UV radiation at a third wavelength of, for example, about 365 nanometers. This first wavelength conversion means here comprises a first or midrange phosphor plate 76 that is fixedly mounted within housing 64. Phosphor plate 76 here comprises a borosilicate, or like glass that is coated with a phosphor coating that converts 254nm ultraviolet (short wave ultraviolet) to about 312nm ultraviolet (midrange ultraviolet).

Superimposed over plate 76 is a short wave UV filter 78 which blocks ambient white visible light, while transmitting 254nm, 312nm and 365nm ultraviolet radiation.

The second wavelength conversion means of this latest form of the invention comprises a second or long wave UV phosphor plate 80 that is removably carried by housing 64 within a slot 82. Plate 80, which is coated with a phosphor, can be constructed from borosilicate glass, quartz glass, hard glass, lime glass, or Plexiglas that only transmits 365nm ultraviolet radiation. Superimposed over plate 80 is a long wave UV transmitting filter 84 that transmits only 365nm ultraviolet radiation and effectively blocks ambient white, visible light transmission. As illustrated in the drawings, plate 80 and filter 84 are disposed at a location intermediate plate 76 and element 74. With the construction shown in the drawings, if desired plate 80 can be readily removed from the housing and replaced with a plate of alternate construction.

Turning next to figures 16 and 17, still another form of transilluminator of the invention for irradiation is there shown for use in controllably irradiating an object with ultraviolet radiation. This form of the invention is also similar in many respects to that shown in figures 10 through 13 and like numerals are used in figures 16 and 17 to identify like components. This alternate form of the invention, which comprises an apparatus for changing a UV source to a multiple UV

wavelength source with or without a UV transmitting, ambient white blocking filter, includes a housing 88 having interconnected top, bottom and sidewalls 90, 92, and 94 respectively that define an internal chamber 96. Carried by top wall 90 is a UV transmitting, light blocking element 74 here provided in the form of a borosilicate glass. Element 74 includes a planar upper surface 74a that is adapted to removably carry an assemblage 98 made up of a glass or other appropriate material plate 100 having first and second surfaces 100a and 100b and phosphor coating 102, which is affixed to surface 100b, is designed to convert ultraviolet radiation at a first wavelength to ultraviolet radiation at a second wavelength. Upper surface 100a of plate 100 is substantially planar and is adapted to support a specimen that is to be irradiated. In the performance of certain operations assemblage 98 can be readily removed from the apparatus and, if desired, can be replaced by an assembly having different characteristics.

As in the previously described embodiments of the invention, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit UV radiation at a first wavelength of, for example, 254 nanometers.

Positioned between the array of lamps 24a and element 74 is fixedly mounted plate 104 that is coated with a phosphor coating 106 that is designed to convert UV radiation at a first wavelength to UV radiation at a second wavelength. Fixedly mounted between plate 104 and plate 74 is a filter 108 that is the character

well understood by those skilled in the art and functions to filter out certain UV wavelengths.

Referring to figure 16A there is shown an alternate form of conversion plate 104a that is coated with a phosphor coating 106a. Plate 104a, which can be constructed from borosilicate, quartz, plastic or like materials, has a generally planar upper surface 105 and a grooved surface 107 which carriers the phosphor coating 106a. The novel step of grooving surface 107 substantially increases the surface area to which the phosphor can adhere. Additionally, as indicated by the arrows of figure 16A, the UV radiation emitted from the UV sources 24a is uniquely scattered as it impinges on the irregular, grooved surface, thereby increasing the diffusion of the light as it is converted to a selected wavelength by the converting phosphor. The uniformly grooved surface 107 not only increases the dispersion of the light, but also enhances the uniformity thereof.

Turning next to figure 16B, still another form of conversion plate 104b that is coated with a phosphor coating 106a, is there shown. Plate 104b, which can be constructed from borosilicate, quartz, plastic or like materials, has opposed grooved surfaces 107, both of which carry the phosphor coating 106a. As indicated by the arrows of figure 16B, the UV radiation emitted from the UV sources 24a is uniquely deflected by the angled walls of the grooved surfaces 107 as it is converted to a selected wavelength by the converting phosphor.

Figure 16C shows yet another form of conversion plate 104c that is coated with a phosphor coating 106a. Plate 104c, which can be constructed from borosilicate, quartz, plastic or like materials, is of a similar configuration to conversion plate 104b save for the fact that the grooved surfaces are offset rather than being aligned as shown in figure 16B. As in the previously described embodiment of the invention both of the grooved surfaces are controllably coated by a selected conversion phosphor.

Referring to figure 16D still another form of conversion plate 104d that is coated with a phosphor coating 106a. Plate 104d is identical in construction to plate 104b, but only one surface of the plate is coated with a phosphor coating 106a.

It is to be understood that, while the drawing show that the phosphor coating fills the grooves in the plates, for certain applications only the surface of the grooves are evenly and more lightly coated with the selected phosphor.

As previously mentioned, the advantages of the plate configuration shown in figures 16A, 16B, 16C and 16D include the provision of greater surface areas for the phosphor to adhere to and greater scattering or diffusion of the radiation to thereby enhance the uniformity of emission.

As in the previously described embodiments, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit

UV radiation at a first wavelength of, for example, 254 nanometers.

Positioned between the array of lamps 24a and element 74 is fixedly mounted plate 104 that is strategically coated with a phosphor coating 106. Fixedly mounted between plate 104 and plate 74 is the previously identified filter 108.

Referring to figures 18 and 19 yet, another form of transilluminator of the invention is there shown. This form of the invention which permits the selective exposure of a sample with broadband UV of about 312nm and about 365nm in a simple, cost effective manner, is similar in many respects to that shown in figures 14 through 17 and like numerals are used in figures 18 and 19 to identify like components. This latest form of the invention comprises a housing 88 having interconnected top, bottom and sidewalls 90, 92, and 94 respectively that define an internal chamber 96. Carried by top wall 90 is a UV transmitting, light blocking element 74 here provided in the form of a borosilicate glass. Element 74 includes a planar upper surface 74a that is adapted to removably carry an assemblage 98 made up of a glass plate 100 having first and second surfaces 100a and 100b and a phosphor coating 102 affixed to surface 100b that is designed to convert ultraviolet radiation at a first wavelength to ultraviolet radiation at a second wavelength. Upper surface 100a is substantially planar and adapted to support a specimen that is to be irradiated. In the performance of certain operations assemblage 98 can be readily removed from the apparatus and, if desired, can be replaced by an assembly

having different characteristics. This latest form of the invention, element 74 includes a planar upper surface 74a that is adapted to carry an article, such as a specimen that is to be irradiated. Element 74 can be constructed of a suitable glass or Plexiglas material that transmits only 365nm bandwidth radiation.

As in the previously described embodiments, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit UV radiation at a first wavelength of, for example, 254 nanometers.

Positioned between the array of lamps 24a and element 74 is a fixedly mounted plate 112 that is coated with a mixture of phosphor coatings 114 which converts 254nm radiation (short wave UV) to a broadband ultraviolet radiation of between approximately 312nm and approximately 365nm. Removably mounted between plate 112 and plate 74 is a filter 113 for blocking passage of all but UV radiation at approximately the 365nm bandwidth. It is to be noted that because of the unique, removable filter 113 which is embodied in this latest form of the apparatus of the invention, two wavelengths of ultraviolet are permitted, namely a wavelength of approximately 365nm and a wavelength of approximately 312nm. More particularly, when filter 113 is in position between plates 74 and 112, the transmission of ultraviolet radiation is restricted to only the 365nm bandwidth. Conversely, when filter 112 is retracted from the housing, transmission of ultraviolet radiation at wavelengths of both in 365nm and 312nm is permitted.

Turning next to figures 20 and 21, still another form of transilluminator of the invention for controllably irradiating an object with ultraviolet radiation is there shown. This form of the invention, which enables the user to change UV wavelengths without having to use a multiplicity of UV lamps emitting radiation of differing wavelengths, is also similar in some respects to that shown in figures 10 through 13 and like numerals are used in figures 20 and 21 to identify like components. This alternate form of the invention comprises a housing 116 having a top portion 116a and a bottom portion 116b. Top portion 116a, which is slidably receivable over bottom portion 116b includes interconnected top, front, back, bottom and sidewalls 118, 120, 122, 124 and 126 respectively. Bottom portion 116b includes top, bottom and sidewalls 128, 130 and 132 respectively. Carried by top wall 118 is a UV transmitting, light blocking element 134 here provided in the form of a borosilicate glass. Superimposed of element 134 is an ultraviolet transmitting filter 136 that only transmits a bandwidth of 365nm ultraviolet radiation while blocking ambient white light transmission. Filter 136 includes a generally planar top surface 136a that is adapted to support an article, such as the specimen that is to be irradiated.

Borosilicate glass, or light blocking element 134, like the previously identified element 74, functions to create a platform that minimizes the transmission of 254nm ultraviolet radiation, while effectively transmitting a

midrange 312nm ultraviolet radiation and above. It is to be understood that blocking element 134 can be constructed of a quartz material, a hard glass, such as chemical Pyrex, limeglass, or ultraviolet transmitting Plexiglass. Long wave UV transmitting filter 136 transmits only 365nm ultraviolet radiation and effectively blocks ambient white light transmission.

As in the earlier described embodiments of the invention, and as illustrated in the drawings, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit UV radiation at a first wavelength of, for example, 254 nanometers.

Positioned between the array of lamps 24a and element 134 is a midrange phosphor plate 140 that is fixedly mounted within housing portion 116b.The phosphor plate 140 here comprises a borosilicate, or like glass that is coated with a phosphor coating that converts 254nm ultraviolet (short wave ultraviolet) to 312nm ultraviolet (midrange ultraviolet).

Mounted on plate 140 is a short wave UV filter 142 which blocks ambient white light, while transmitting 254nm, 312nm and 365nm ultraviolet radiation.

With the construction shown figures 20 and 21, the upper portion of 116a of the housing can be readily separated from the lower portion 116b so as to expose the upper surface 142a of filter 142. With the upper portion 116a of the housing removed, the specimen to be irradiated can be placed directly on the upper surface

142a of the filter.

Turning next to figures 22 and 23, still another form of transilluminator of the invention is there shown. This form of the invention uniquely embodies a novel fibrous or mesh assembly that has been coated or impregnated with selected wavelength conversion phosphors. This latest form of the invention is similar in many respects to that shown in figures 18 and 19 and, once again, like numerals are used in figures 22 and 23 to identify like components. This latest form of the invention comprises a housing 148 having interconnected top, bottom and sidewalls 150,152 and 154 respectively that define an internal chamber 156. Carried by top wall 150 is a UV transmitting, light blocking element 74 here provided in the form of a borosilicate glass. As before, element 74 includes a planar upper surface 74a that is adapted to carry an article, such as a specimen that is to be irradiated. Element 74 can be constructed of a suitable glass or Plexiglas material that transmits only 365nm bandwidth radiation.

As in the previously described embodiments, the UV sources here comprises a plurality of spaced-apart, ultraviolet-light-emitting lamps 24a that emit UV radiation at a first wavelength of, for example, 254 nanometers.

Positioned between the array of lamps 24a and element 74 is a removably mounted filter 160. Mounted between filter 160 and lamps 24a is a borosilicate glass plate 162 and a conversion means for converting ultraviolet radiation at a first

wavelength to ultraviolet radiation at a second wavelength. This conversion means here uniquely comprises a novel phosphor coated mesh assembly 164 which is of general character illustrated in figures 24 and 25. As best seen and figure 24, mesh assembly 164 includes supporting means here provided as a supporting frame 166 that functions to support a mesh substrate 168 in a stretched, generally planar configuration. Mesh substrate 168 comprises a multiplicity of spaced apart, interconnected elements 169, each of which is at least partially coated with a phosphor so as to create a large area, uniform lighting background. Mesh substrate 168 can be formed from metal, plastic, glass, quartz and like materials. The mesh substrate can be coated with various wave shift phosphors 170, such as phosphors that will convert 254nm ultraviolet radiation to 312nm ultraviolet radiation; will convert 254nm ultraviolet radiation to 365nm ultraviolet radiation; will convert 354nm ultraviolet radiation to 302nm/365nm radiation (broadband mix); and will converts 254nm ultraviolet radiation to a UV, white light combination. Wave-shift phosphors 170 can also comprise a mixture of visible conversion spectra phosphors and ultraviolet phosphors.

As in certain of the of the earlier described embodiments of the invention, light sources 24a are positioned over a corrugated reflector 172 (figure 22) which functions to uniformly reflect the light omitted from the light sources upwardly into internal chamber 156. As before, reflector 172 can be a flat reflector or a

dimpled plate reflector.

Having now described the invention in detail in accordance with the requirements of the patent statutes, those skilled in this art will have no difficulty in making changes and modifications in the individual parts or their relative assembly in order to meet specific requirements or conditions. Such changes and modifications may be made without departing from the scope and spirit of the invention, as set forth in the following claims.